

APPENDIX D
CALCULATION OF BENEFITS

ANALYSIS TECHNIQUES AND ASSUMPTIONS

An analysis was conducted to assess the benefit cost ratios for congestion created by incidents after the implementation of ITS. Based on other recent studies, it was assumed for this analysis that the travel time delay will be reduced by 25 percent. It was also assumed that the average fuel efficiency is 15 miles per gallon with speeds under 35 mph, the cost of fuel is \$1.20 per gallon and the average speed during the delay period is 10 mph without ITS implementation.

The average speed is a function of vehicle volumes. Volume is inversely proportional to speed. For example, when volume increases, speed decreases. A representative average queue length of 3 miles is used for this analysis. During times of congestion, the average queue length is assumed to be the same, however the flow rates differ.

The benefits in the short term are based on 1993 ADT values as documented in the MDOT Sufficiency Ratings. The Long Term benefits are based on projected 2015 ADT volumes provided by GRETS. The Medium term benefits are based on volumes extrapolated from the 1993 and the projected 2015 volumes. The number of accidents is assumed to grow at the same rate as the ADT's over the time frames in order to best estimate the benefits of the system in future conditions.

It is assumed that 40 percent of the ADT encounters 30 percent of the total accidents as posted for the 1993 calendar year in incident sensitive areas (shown in Figure 2-9). It is also assumed that only 10 percent of the ADT will encounter 10 percent of the total accidents in the non-sensitive areas.

The following sections describe detailed analysis techniques used in calculating the benefits derived from implementing an incident detection and traffic management system as a whole using mainline detectors, video surveillance, and various modes of information dissemination (VMS, HAR, public broadcast, etc.).

Travel Delay Time Savings

Assuming the average queue length of 3 miles, the existing travel delay time can be estimated by using the following equation:

$$\begin{aligned}\text{Travel Delay Time} &= (\text{average queue length}/\text{average delay velocity}) \times 60 \\ &= (3 \text{ miles}/10 \text{ mph}) \times 60 \text{ min/hour} = \underline{18 \text{ minutes}}\end{aligned}$$

Using a 25 percent reduction in travel time delay with ITS implementation, the travel delay time is:

$$\text{Travel Delay Time} = 18 \text{ minutes} \times (1 - .25) = \underline{13.5 \text{ minutes}}$$

As stated in Chapter 6 and above, it is assumed that 40 percent of the ADT encounters 30 percent of the total accidents as posted for the 1993 calendar year in incident sensitive areas. It is also assumed that only 10 percent of the ADT will encounter 10 percent of the total accidents in the non-sensitive areas. It is also assumed that the number of accidents will remain the same during the deployment year.

Using the travel delay times of 18 minutes (no ITS implementation) and 13.5 minutes (with ITS implementation), travel delay time benefits can be determined by the following equation:

$$\begin{aligned}\text{Annual Travel Delay Time (hrs) (without ITS implementation)} \\ &= (\text{ADT} \times 0.4 \text{ (0.1 in non-sensitive segments)} \times 18 \text{ minutes} \times (\# \text{ of} \\ &\quad \text{accidents}) \times 0.3 \text{ (0.1 in non-sensitive segments)})/60 \text{ min/hr}\end{aligned}$$

$$\begin{aligned}\text{Annual Travel Delay Time (hrs) (with ITS implementation)} \\ &= (\text{ADT} \times 0.4 \text{ (0.1 in non-sensitive segments)} \times 13.5 \text{ minutes} \times (\# \text{ of} \\ &\quad \text{accidents}) \times 0.3 \text{ (0.1 in non-sensitive segments)})/60 \text{ min/hr}\end{aligned}$$

Benefits and savings can be calculated by taking the difference of the two results. Tables D-1 through D-3 show the breakdown of benefits in travel delay time savings for each corridor segment induced by incident congestion.

To quantify the dollar amounts of the travel delay time, a rate of \$10.00 per congested hour is used in determining the loss of productivity for incident congestion. Tables D-4 through D-6 show the dollars associated in the loss of productivity for incident congestion.

Table D-1 US 131 Travel Delay Time Savings

ROADWAY SEGMENT		VOLUME (ADT)	NUMBER OF ACCIDENTS	ANNUAL TRAVEL DELAY TIME (EXIST.) (HRS)	ANNUAL TRAVEL DELAY TIME (W/IMPROV.) (HRS)	TOTAL ANNUAL DELAY SAVINGS (HRS)
FROM	TO					
68th St.	Wyoming Limit	66,100	18	42,833	32,125	10,708
Wyoming Limit	54th St.	66,100	18	3,569	2,677	892
54th St.	44th St.	70,700	19	48,359	36,269	12,090
44th St.	36th St.	83,100	20	59,832	44,874	14,958
36th St.	28th St.	90,000	56	181,440	136,080	45,360
28th St.	G. R. Limits	104,000	40	149,760	112,320	37,440
G. R. Limits	Burton St.	104,000	17	63,648	47,736	15,912
Burton St.	Hall St.	107,000	51	196,452	147,339	49,113
Hall St.	Franklin St.	114,000	47	192,888	144,666	48,222
Franklin St.	Wealthy St.	115,000	35	144,900	108,675	36,225
Wealthy St.	Market St.	121,000	48	209,088	156,816	52,272
Market St.	M-45	128,000	61	281,088	210,816	70,272
M-45	I-196	125,000	59	265,500	199,125	66,375
I-196	Leonard St.	108,000	78	303,264	227,448	75,816
Leonard St.	Ann St.	108,000	39	151,632	113,724	37,908
Ann St.	I-296 Conn.	99,000	27	96,228	72,171	24,057
I-296 Conn.	I-96	56,000	29	58,464	43,848	14,616
I-96	Walker Limits	61,000	23	50,508	37,881	12,627
Walker Limits	West River Drive	61,000	33	72,468	54,351	18,117
West River Drive	Post Drive	55,800	79	158,695	119,021	39,674
TOTAL:				2,730,616	2,047,962	682,654

Table D-2 I-196 Travel Delay Time Savings

ROADWAY SEGMENT		VOLUME (ADT)	NUMBER OF ACCIDENTS	ANNUAL TRAVEL DELAY TIME (EXIST.) (HRS)	ANNUAL TRAVEL DELAY TIME (W/IMPROV.) (HRS)	TOTAL ANNUAL DELAY SAVINGS (HRS)
FROM	TO					
Kent Cty Line	44th Ave.	49,850	14	2,094	1,570	523
44th Ave.	Chicago Dr.	52,650	32	5,054	3,791	1,264
Chicago Dr.	28th St.	70,500	25	63,450	47,588	15,863
28th St.	Business 196	63,250	22	4,175	3,131	1,044
Business 196	Market St.	45,000	12	1,620	1,215	405
Market St.	Rte. M-45	41,000	25	36,900	27,675	9,225
Rte. M-45	Lane Ave.	41,000	26	38,376	28,782	9,594
Lane Ave.	US 131	66,000	18	42,768	32,076	10,692
US 131	Business 131	77,000	42	116,424	87,318	29,106
Business 131	College Ave.	77,000	14	38,808	29,106	9,702
College Ave.	Fuller St.	70,000	43	108,360	81,270	27,090
Fuller St.	I-96	80,000	26	74,880	56,160	18,720
TOTAL:				532,909	399,681	133,227

Table D-3 I-96 Travel Delay Time Savings

ROADWAY SEGMENT		VOLUME (ADT)	NUMBER OF ACCIDENTS	ANNUAL TRAVEL DELAY TIME (EXIST.) (HRS)	ANNUAL TRAVEL DELAY TIME (W/IMPROV.) (HRS)	TOTAL ANNUAL DELAY SAVINGS (HRS)
FROM	TO					
16 th Ave.*	Kent Cty Line*	31,760	10	953	715	238
Kent Cty Line	Fruit Ridge Ave.	39,700	12	1,429	1,072	357
Fruit Ridge Ave.	Walker Ave.	59,300	19	3,380	2,535	845
Walker Ave.	Rte. M-37	64,500	25	58,050	43,538	14,513
Rte. M-37	I-296	98,000	4	14,112	10,584	3,528
I-296	US 131	43,000	15	23,220	17,415	5,805
US 131	Walker Limits	43,000	8	12,384	9,288	3,096
Walker Limits	M-44 Connector	78,000	15	3,510	2,633	878
M-44 Connector	Leonard St.	56,000	31	5,208	3,906	1,302
Leonard St.	I-196	39,000	5	585	439	146
I-196	M-37, M-44	83,000	17	50,796	38,097	12,699
M-37, M-44	M-21	69,000	14	34,776	26,082	8,694
M-21	Cascade Rd.	77,390	26	6,036	4,527	1,509
Cascade Rd.	28th St.	51,150	46	7,059	5,294	1,765
TOTAL:				221,498	166,124	55,375

* - estimates, no data available

Table D-4 US 131 Travel Delay Cost Savings (Productivity Savings)

ROADWAY SEGMENT		EG. LENGTH (MILES)	VOLUME (ADT)	NUMBER OF ACCIDENTS	ANNUAL TRAVEL DELAY COST (EX)	ANNUAL TRAVEL DELAY (W/IMPROV)	TOTAL ANNUAL DELAY SAVINGS	ANN. DELAY SAVINGS/MILI
FROM	TO							
68th St.	Wyoming Limit	0.96	66,100	18	\$428,328	\$321,246	\$107,082	\$111,544
Wyoming Limit	54th St.	0.78	66,100	18	\$35,694	\$26,771	\$8,924	\$11,411
54th St.	44th St.	1.27	70,700	19	\$483,588	\$362,691	\$120,897	\$95,194
44th St.	36th St.	1.01	83,100	20	\$598,320	\$448,740	\$149,580	\$147,660
36th St.	28th St.	1.01	90,000	56	\$1,814,400	\$1,360,800	\$453,600	\$450,000
28th St.	G. R. Limits	0.53	104,000	40	\$1,497,600	\$1,123,200	\$374,400	\$710,436
G. R. Limits	Burton St.	0.51	104,000	17	\$636,480	\$477,360	\$159,120	\$310,175
Burton St.	Hall St.	0.98	107,000	51	\$1,964,520	\$1,473,390	\$491,130	\$500,132
Hall St.	Franklin St.	0.52	114,000	47	\$1,928,880	\$1,446,660	\$482,220	\$932,727
Franklin St.	Wealthy St.	0.43	115,000	35	\$1,449,000	\$1,086,750	\$362,250	\$844,406
Wealthy St.	Market St.	0.54	121,000	48	\$2,090,880	\$1,568,160	\$522,720	\$962,652
Market St.	M-45	0.27	128,000	61	\$2,810,880	\$2,108,160	\$702,720	\$2,602,667
M-45	I-196	0.57	125,000	59	\$2,655,000	\$1,991,250	\$663,750	\$1,160,402
I-196	Leonard St.	0.92	108,000	78	\$3,032,640	\$2,274,480	\$758,160	\$825,882
Leonard St.	Ann St.	0.76	108,000	39	\$1,516,320	\$1,137,240	\$379,080	\$500,106
Ann St.	I-296 Conn.	1.02	99,000	27	\$962,280	\$721,710	\$240,570	\$236,084
I-296 Conn.	I-96	0.87	56,000	29	\$584,640	\$438,480	\$146,160	\$167,807
I-96	Walker Limits	0.58	61,000	23	\$505,080	\$378,810	\$126,270	\$216,959
Walker Limits	West River Drive	0.84	61,000	33	\$724,680	\$543,510	\$181,170	\$216,452
West River Drive	Post Drive	3.98	55,800	79	\$1,586,952	\$1,190,214	\$396,738	\$99,608
TOTAL:		18.35			\$27,306,162	\$20,479,622	\$6,826,541	\$371,937

Table D-5 I-196 Travel Delay Cost Savings (Productivity Savings)

ROADWAY SEGMENT		EG. LENGTH (MILES)	VOLUME (ADT)	NUMBER OF ACCIDENTS	ANNUAL TRAVEL DELAY COST (EX)	ANNUAL TRAVEL DELAY (W/IMPROV)	TOTAL ANNUAL DELAY SAVINGS	ANN. DELAY SAVINGS/MILI
FROM	TO							
Kent Cty Line	44th Ave.	0.62	49,850	14	\$20,937	\$15,703	\$5,234	\$8,402
44th Ave.	Chicago Dr.	1.39	52,650	32	\$50,544	\$37,908	\$12,636	\$9,123
Chicago Dr.	28th St.	1.04	70,500	25	\$634,500	\$475,875	\$158,625	\$152,818
28th St.	Business 196	1.72	63,250	22	\$41,745	\$31,309	\$10,436	\$6,071
Business 196	Market St.	0.32	45,000	12	\$16,200	\$12,150	\$4,050	\$12,857
Market St.	Rte. M-45	1.53	41,000	25	\$369,000	\$276,750	\$92,250	\$60,492
Rte. M-45	Lane Ave.	0.78	41,000	26	\$383,760	\$287,820	\$95,940	\$123,794
Lane Ave.	US 131	0.70	66,000	18	\$427,680	\$320,760	\$106,920	\$152,961
US 131	Business 131	0.59	77,000	42	\$1,164,240	\$873,180	\$291,060	\$494,160
Business 131	College Ave.	0.54	77,000	14	\$388,080	\$291,060	\$97,020	\$179,667
College Ave.	Fuller St.	0.87	70,000	43	\$1,083,600	\$812,700	\$270,900	\$311,379
Fuller St.	I-96	2.00	80,000	26	\$748,800	\$561,600	\$187,200	\$93,600
TOTAL:		12.08			\$5,329,086	\$3,996,815	\$1,332,272	\$110,306

Table D-6 I-96 Travel Delay Cost Savings (Productivity Savings)

ROADWAY SEGMENT		EG. LENGTH (MILES)	VOLUME (ADT)	NUMBER OF ACCIDENTS	ANNUAL TRAVEL DELAY COST (EX)	ANNUAL TRAVEL DELAY (W/IMPROV)	TOTAL ANNUAL DELAY SAVINGS	ANN. DELAY SAVINGS/MILI
FROM	TO							
16 th Ave.*	Kent Cty Line*	2.00	31,760	10	\$9,528	\$7,146	\$2,382	\$1,191
Kent Cty Line	Fruit Ridge Ave.	1.49	39,700	12	\$14,292	\$10,719	\$3,573	\$2,398
Fruit Ridge Ave.	Walker Ave.	1.70	59,300	19	\$33,801	\$25,351	\$8,450	\$4,971
Walker Ave.	Rte. M-37	2.12	64,500	25	\$580,500	\$435,375	\$145,125	\$68,326
Rte. M-37	I-296	0.16	98,000	4	\$141,120	\$105,840	\$35,280	\$224,713
I-296	US 131	0.98	43,000	15	\$232,200	\$174,150	\$58,050	\$58,994
US 131	Walker Limits	0.27	43,000	8	\$123,840	\$92,880	\$30,960	\$116,830
Walker Limits	M-44 Connector	1.36	78,000	15	\$35,100	\$26,325	\$8,775	\$6,476
M-44 Connector	Leonard St.	3.47	56,000	31	\$52,080	\$39,060	\$13,020	\$3,752
Leonard St.	I-196	0.80	39,000	5	\$5,850	\$4,388	\$1,463	\$1,824
I-196	M-37, M-44	0.47	83,000	17	\$507,960	\$380,970	\$126,990	\$27,927
M-37, M-44	M-21	0.61	69,000	14	\$347,760	\$260,820	\$86,940	\$142,525
M-21	Cascade Rd.	1.61	77,390	26	\$60,364	\$45,273	\$15,091	\$9,368
Cascade Rd.	28th St.	2.91	51,150	46	\$70,587	\$52,940	\$17,647	\$6,060
TOTAL:		17.95			\$2,214,982	\$1,661,237	\$553,746	\$30,854

* - estimates, no data available

Fuel Usage

Further calculations can be made to estimate the average vehicle velocities upon implementing incident and freeway management systems.

$$\begin{aligned}\text{Average speed to travel 3 mi.} &= (\text{average queue length/travel delay time}) \times 60 \\ &= (3\text{mi./}13.5 \text{ minutes}) \times 60 \\ &= \underline{13.3 \text{ mph (with implementation)}}\end{aligned}$$

Again, the average speed during the delay period without ITS implementation is assumed to be 10 mph.

Using the established fuel efficiency rating of 15 mpg, fuel use can be determined:

$$\begin{aligned}\text{Fuel Use} &= \text{queue length/fuel efficiency} \\ &= 3 \text{ mi./}15 \text{ mpg} \\ &= \underline{0.20 \text{ gallons}}\end{aligned}$$

Assuming that the fuel burn rate at 10 mph and 13.3 mph are the same, a fuel rate factor can be calculated as follows:

$$\begin{aligned}R_F &= \text{Fuel Use/Delay Travel Time} \\ &= 0.2 \text{ gal./}3.5 \text{ minutes} \\ &= \underline{0.015 \text{ gal./min.}}\end{aligned}$$

Using the calculated rate factor R_F , the amount of fuel usage can be calculated for the existing conditions.

$$\begin{aligned}\text{Fuel Use} &= 18 \text{ minutes} \times 0.015 \text{ gal./min.} \\ &= \underline{0.27 \text{ gallons}}\end{aligned}$$

Total fuel use under incident related congestion conditions can be calculated using the following equation:

$$\text{Total Fuel Use (without ITS implementation)} = \text{ADT} \times 0.4 \text{ (0.1 in non-sensitive areas)} \times 0.27 \times \# \text{ of incidents} \times 0.3 \text{ (0.1 in non-sensitive areas)}$$

$$\text{Total Fuel Use (with ITS implementation)} = \text{ADT} \times 0.4 \text{ (0.1 in non-sensitive areas)} \times 0.20 \times \# \text{ of incidents} \times 0.3 \text{ (0.1 in non-sensitive areas)}$$

Tables D-7 through D-9 show the fuel savings in gallons using the above equations as applied to each corridor segment.

The savings in fuel cost can be calculated by multiplying the fuel cost per gallon (\$1.20) by the number of gallons used annually. Tables D-10 through D-12 show the fuel savings in dollars.

Table D-7 US 131 Fuel Use Savings

ROADWAY SEGMENT		VOLUME (ADT)	NUMBER OF ACCIDENTS	TOTAL ANNUAL FUEL USE (EXIST.) (GAL.)	TOTAL ANNUAL FUEL USE (W/IMPROV.) (GAL.)	TOTAL ANNUAL FUEL SAVINGS (GAL.)
FROM	TO					
68th St.	Wyoming Limit	66,100	18	38,074	28,555	9,518
Wyoming Limit	54th St.	66,100	18	3,173	2,380	793
54th St.	44th St.	70,700	19	42,986	32,239	10,746
44th St.	36th St.	83,100	20	53,184	39,888	13,296
36th St.	28th St.	90,000	56	161,280	120,960	40,320
28th St.	G. R. Limits	104,000	40	133,120	99,840	33,280
G. R. Limits	Burton St.	104,000	17	56,576	42,432	14,144
Burton St.	Hall St.	107,000	51	174,624	130,968	43,656
Hall St.	Franklin St.	114,000	47	171,456	128,592	42,864
Franklin St.	Wealthy St.	115,000	35	128,800	96,600	32,200
Wealthy St.	Market St.	121,000	48	185,856	139,392	46,464
Market St.	M-45	128,000	61	249,856	187,392	62,464
M-45	I-196	125,000	59	236,000	177,000	59,000
I-196	Leonard St.	108,000	78	269,568	202,176	67,392
Leonard St.	Ann St.	108,000	39	134,784	101,088	33,696
Ann St.	I-296 Conn.	99,000	27	85,536	64,152	21,384
I-296 Conn.	I-96	56,000	29	51,968	38,976	12,992
I-96	Walker Limits	61,000	23	44,896	33,672	11,224
Walker Limits	West River Drive	61,000	33	64,416	48,312	16,104
West River Drive	Post Drive	55,800	79	141,062	105,797	35,266
TOTAL:				2,427,214	1,820,411	606,804

Table D-8 I-196 Fuel Use Savings

ROADWAY SEGMENT		VOLUME (ADT)	NUMBER OF ACCIDENTS	TOTAL ANNUAL FUEL USE (EXIST.) (GAL.)	TOTAL ANNUAL FUEL USE (W/IMPROV.) (GAL)	TOTAL ANNUAL FUEL SAVINGS (GAL.)
FROM	TO					
Kent Cty Line	44th Ave.	49,850	14	1,861	1,396	465
44th Ave.	Chicago Dr.	52,650	32	4,493	3,370	1,123
Chicago Dr.	28th St.	70,500	25	56,400	42,300	14,100
28th St.	Business 196	63,250	22	3,711	2,783	928
Business 196	Market St.	45,000	12	1,440	1,080	360
Market St.	Rte. M-45	41,000	25	32,800	24,600	8,200
Rte. M-45	Lane Ave.	41,000	26	34,112	25,584	8,528
Lane Ave.	US 131	66,000	18	38,016	28,512	9,504
US 131	Business 131	77,000	42	103,488	77,616	25,872
Business 131	College Ave.	77,000	14	34,496	25,872	8,624
College Ave.	Fuller St.	70,000	43	96,320	72,240	24,080
Fuller St.	I-96	80,000	26	66,560	49,920	16,640
TOTAL:				473,697	355,272	118,424

Table D-9 I-96 Fuel Use Savings

ROADWAY SEGMENT		VOLUME (ADT)	NUMBER OF ACCIDENTS	TOTAL ANNUAL FUEL USE (EXIST.) (GAL.)	TOTAL ANNUAL FUEL USE (W/IMPROV.) (GAL)	TOTAL ANNUAL FUEL SAVINGS (GAL.)
FROM	TO					
16 th Ave.*	Kent Cty Line*	31,760	10	847	635	212
Kent Cty Line	Fruit Ridge Ave.	39,700	12	1,270	953	318
Fruit Ridge Ave.	Walker Ave.	59,300	19	3,005	2,253	751
Walker Ave.	Rte. M-37	64,500	25	51,600	38,700	12,900
Rte. M-37	I-296	98,000	4	12,544	9,408	3,136
I-296	US 131	43,000	15	20,640	15,480	5,160
US 131	Walker Limits	43,000	8	11,008	8,256	2,752
Walker Limits	M-44 Connector	78,000	15	3,120	2,340	780
M-44 Connector	Leonard St.	56,000	31	4,629	3,472	1,157
Leonard St.	I-196	39,000	5	520	390	130
I-196	M-37, M-44	83,000	17	45,152	33,864	11,288
M-37, M-44	M-21	69,000	14	30,912	23,184	7,728
M-21	Cascade Rd.	77,390	26	5,366	4,024	1,341
Cascade Rd.	28th St.	51,150	46	6,274	4,706	1,569
TOTAL:				196,887	147,665	49,222

* - estimates, no data available

Table D-10 US 131 Fuel Cost Savings

ROADWAY SEGMENT		SEG. LENGTH (MILES)	VOLUME (ADT)	NUMBER OF ACCIDENTS	TOTAL ANN. FUEL USE (EXIST.)	TOTAL ANN. FUEL USE (W/IMPROV.)	TOTAL ANNUAL FUEL SAVINGS	FUEL SAVINGS PER MILE
FROM	TO							
68th St.	Wyoming Limit	0.96	66,100	18	\$45,688	\$34,266	\$11,422	\$11,898
Wyoming Limit	54th St.	0.78	66,100	18	\$3,807	\$2,856	\$952	\$1,217
54th St.	44th St.	1.27	70,700	19	\$51,583	\$38,687	\$12,896	\$10,154
44th St.	36th St.	1.01	83,100	20	\$63,821	\$47,866	\$15,955	\$15,750
36th St.	28th St.	1.01	90,000	56	\$193,536	\$145,152	\$48,384	\$48,000
28th St.	G. R. Limits	0.53	104,000	40	\$159,744	\$119,808	\$39,936	\$75,780
G. R. Limits	Burton St.	0.51	104,000	17	\$67,891	\$50,918	\$16,973	\$33,085
Burton St.	Hall St.	0.98	107,000	51	\$209,549	\$157,162	\$52,387	\$53,347
Hall St.	Franklin St.	0.52	114,000	47	\$205,747	\$154,310	\$51,437	\$99,491
Franklin St.	Wealthy St.	0.43	115,000	35	\$154,560	\$115,920	\$38,640	\$90,070
Wealthy St.	Market St.	0.54	121,000	48	\$223,027	\$167,270	\$55,757	\$102,683
Market St.	M-45	0.27	128,000	61	\$299,827	\$224,870	\$74,957	\$277,618
M-45	I-196	0.57	125,000	59	\$283,200	\$212,400	\$70,800	\$123,776
I-196	Leonard St.	0.92	108,000	78	\$323,482	\$242,611	\$80,870	\$88,094
Leonard St.	Ann St.	0.76	108,000	39	\$161,741	\$121,306	\$40,435	\$53,345
Ann St.	I-296 Conn.	1.02	99,000	27	\$102,643	\$76,982	\$25,661	\$25,182
I-296 Conn.	I-96	0.87	56,000	29	\$62,362	\$46,771	\$15,590	\$17,899
I-96	Walker Limits	0.58	61,000	23	\$53,875	\$40,406	\$13,469	\$23,142
Walker Limits	West River Drive	0.84	61,000	33	\$77,299	\$57,974	\$19,325	\$23,088
West River Drive	Post Drive	3.98	55,800	79	\$169,275	\$126,956	\$42,319	\$10,625
TOTAL:		18.35			\$2,912,657	\$2,184,493	\$728,164	\$39,673

Table D-11 I-196 Fuel Cost Savings

ROADWAY SEGMENT		EG. LENGTH (MILES)	VOLUME (ADT)	NUMBER OF ACCIDENTS	TOTAL ANN. FUEL USE (EXIST.)	TOTAL ANN. FUEL USE (W/IMPROV.)	TOTAL ANNUAL FUEL SAVINGS	FUEL SAVINGS PER MILE
FROM	TO							
Kent Cty Line	44th Ave.	0.62	49,850	14	\$2,233	\$1,675	\$558	\$896
44th Ave.	Chicago Dr.	1.39	52,650	32	\$5,391	\$4,044	\$1,348	\$973
Chicago Dr.	28th St.	1.04	70,500	25	\$67,680	\$50,760	\$16,920	\$16,301
28th St.	Business 196	1.72	63,250	22	\$4,453	\$3,340	\$1,113	\$648
Business 196	Market St.	0.32	45,000	12	\$1,728	\$1,296	\$432	\$1,371
Market St.	Rte. M-45	1.53	41,000	25	\$39,360	\$29,520	\$9,840	\$6,452
Rte. M-45	Lane Ave.	0.78	41,000	26	\$40,934	\$30,701	\$10,234	\$13,205
Lane Ave.	US 131	0.70	66,000	18	\$45,619	\$34,214	\$11,405	\$16,316
US 131	Business 131	0.59	77,000	42	\$124,186	\$93,139	\$31,046	\$52,710
Business 131	College Ave.	0.54	77,000	14	\$41,395	\$31,046	\$10,349	\$19,164
College Ave.	Fuller St.	0.87	70,000	43	\$115,584	\$86,688	\$28,896	\$33,214
Fuller St.	I-96	2.00	80,000	26	\$79,872	\$59,904	\$19,968	\$9,984
TOTAL:		12.08			\$568,436	\$426,327	\$142,109	\$11,766

Table D-12 I-96 Fuel Cost Savings

ROADWAY SEGMENT		EG. LENGTH (MILES)	VOLUME (ADT)	NUMBER OF ACCIDENTS	TOTAL ANN. FUEL USE (EXIST.)	TOTAL ANN. FUEL USE (W/IMPROV.)	TOTAL ANNUAL FUEL SAVINGS	FUEL SAVINGS PER MILE
FROM	TO							
16 th Ave.*	Kent Cty Line*	2.00	31,760	10	\$1,016	\$762	\$254	\$127
Kent Cty Line	Fruit Ridge Ave.	1.49	39,700	12	\$1,524	\$1,143	\$381	\$256
Fruit Ridge Ave.	Walker Ave.	1.70	59,300	19	\$3,605	\$2,704	\$901	\$530
Walker Ave.	Rte. M-37	2.12	64,500	25	\$61,920	\$46,440	\$15,480	\$7,288
Rte. M-37	I-296	0.16	98,000	4	\$15,053	\$11,290	\$3,763	\$23,969
I-296	US 131	0.98	43,000	15	\$24,768	\$18,576	\$6,192	\$6,293
US 131	Walker Limits	0.27	43,000	8	\$13,210	\$9,907	\$3,302	\$12,462
Walker Limits	M-44 Connector	1.36	78,000	15	\$3,744	\$2,808	\$936	\$691
M-44 Connector	Leonard St.	3.47	56,000	31	\$5,555	\$4,166	\$1,389	\$400
Leonard St.	I-196	0.80	39,000	5	\$624	\$468	\$156	\$195
I-196	M-37, M-44	0.47	83,000	17	\$54,182	\$40,637	\$13,546	\$29,006
M-37, M-44	M-21	0.61	69,000	14	\$37,094	\$27,821	\$9,274	\$15,203
M-21	Cascade Rd.	1.61	77,390	26	\$6,439	\$4,829	\$1,610	\$999
Cascade Rd.	28th St.	2.91	51,150	46	\$7,529	\$5,647	\$1,882	\$646
TOTAL:		17.95			\$236,265	\$177,199	\$59,066	\$2,961

* - estimates, no data available

Emissions Reduction

Vehicle exhaust emissions can be reduced due to the reduction of incident related congestion. Using the emission rates extrapolated from Figure 6-1 and the annual travel delay time savings calculated previously, the reduction in emissions of CO, HC, and NO, can be calculated as follows:

Reduction in CO = (Travel Delay Savings x (0.94 g CO/sec / 453.6 g/lb) x 3600 sec/hr)/2000 lb/ton

Reduction in HC = (Travel Delay Savings x (0.01 g CO/sec / 453.6 g/lb) x 3600 sec/hr)/2000 lb/ton

Reduction in NO, = (Travel Delay Savings x (0.0085 g CO/sec / 453.6 g/lb) x 3600 sec/hr)/2000 lb/ton

Tables D- 13 to D- 15 show the reductions in vehicle emissions per corridor segment.

Table D-13 US 131 Emission Reductions

ROADWAY SEGMENT		TOTAL CO EMISSIONS SAVINGS (TONS)	TOTAL HC EMISSIONS SAVINGS (TONS)	TOTAL NO _x EMISSIONS SAVINGS (TONS)
FROM	TO			
68th St.	Wyoming Limit	40	0	0
Wyoming Limit	54th St.	3	0	0
54th St.	44th St.	45	0	0
44th St.	36th St.	56	1	1
36th St.	28th St.	169	2	2
28th St.	G. R. Limits	140	1	1
G. R. Limits	Burton St.	59	2	1
Burton St.	Hall St.	183	2	2
Hall St.	Franklin St.	180	2	2
Franklin St.	Wealthy St.	135	1	1
Wealthy St.	Market St.	195	2	2
Market St.	M-45	262	3	2
M-45	I-196	248	3	2
I-196	Leonard St.	283	3	3
Leonard St.	Ann St.	141	2	1
Ann St.	I-296 Conn.	90	1	1
I-296 Conn.	I-96	55	1	0
I-96	Walker Limits	47	1	0
Walker Limits	West River Drive	68	1	1
West River Drive	Post Drive	148	2	1
TOTAL:		2,546	27	23

Table D-14 I-196 Emission Reductions

ROADWAY SEGMENT		TOTAL CO EMISSIONS SAVINGS (TONS)	TOTAL HC EMISSIONS SAVINGS (TONS)	TOTAL NO _x EMISSIONS SAVINGS (TONS)
FROM	TO			
Kent Cty Line	44th Ave.	2	0	0
44th Ave.	Chicago Dr.	5	0	0
Chicago Dr.	28th St.	59	1	1
28th St.	Business 196	4	0	0
Business 196	Market St.	2	0	0
Market St.	Rte. M-45	34	0	0
Rte. M-45	Lane Ave.	36	0	0
Lane Ave.	US 131	40	0	0
US 131	Business 131	109	1	1
Business 131	College Ave.	36	0	0
College Ave.	Fuller St.	101	1	1
Fuller St.	I-96	70	1	1
TOTAL:		497	5	4

Table D-15 I-96 Emission Reductions

ROADWAY SEGMENT		TOTAL CO EMISSIONS SAVINGS (TONS)	TOTAL HC EMISSIONS SAVINGS (TONS)	TOTAL NO _x EMISSIONS SAVINGS (TONS)
FROM	TO			
16 th Ave.*	Kent Cty Line*	1	0	0
Kent Cty Line	Fruit Ridge Ave.	1	0	0
Fruit Ridge Ave.	Walker Ave.	3	0	0
Walker Ave.	Rte. M-37	54	1	0
Rte. M-37	I-296	13	0	0
I-296	US 131	22	0	0
US 131	Walker Limits	12	0	0
Walker Limits	M-44 Connector	3	0	0
M-44 Connector	Leonard St.	5	0	0
Leonard St.	I-196	1	0	0
I-196	M-37, M-44	47	1	0
M-37, M-44	M-21	32	0	0
M-21	Cascade Rd.	6	0	0
Cascade Rd.	28th St.	7	0	0
TOTAL:		207	2	2

* - estimates, no data available